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(54) PSEUDO-8-SHAPED INDUCTOR

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H01F 5/00 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***H01F 5/003*** (2013.01); ***H01F 17/0006*** (2013.01); ***H01F 17/02*** (2013.01); ***H01F 27/346*** (2013.01); ***H01F 41/041*** (2013.01); ***H01L 23/5227*** (2013.01); *H01F 17/0013* (2013.01); *H01F 2017/0046* (2013.01); *H01F 2017/0073* (2013.01); *H01L 2924/0002* (2013.01); *Y10T 29/4902* (2015.01)

(58) **Field of Classification Search**

CPC H01F 5/003; H01F 17/02; H01F 41/041; H01F 27/2823; H01F 19/04; H01F 27/306; H01F 27/28; H01F 27/327

USPC 336/182, 225, 180, 200, 226

See application file for complete search history.

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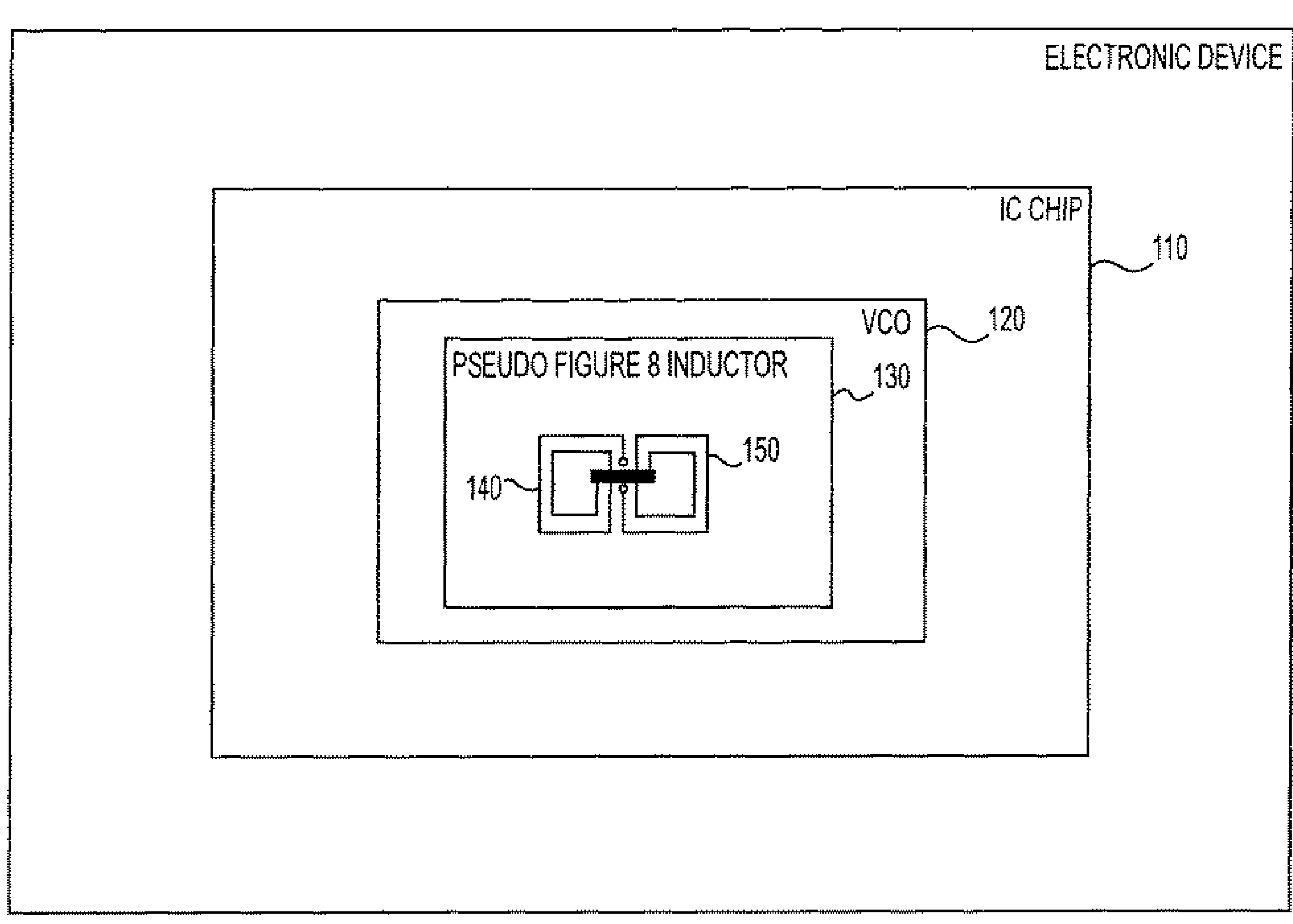
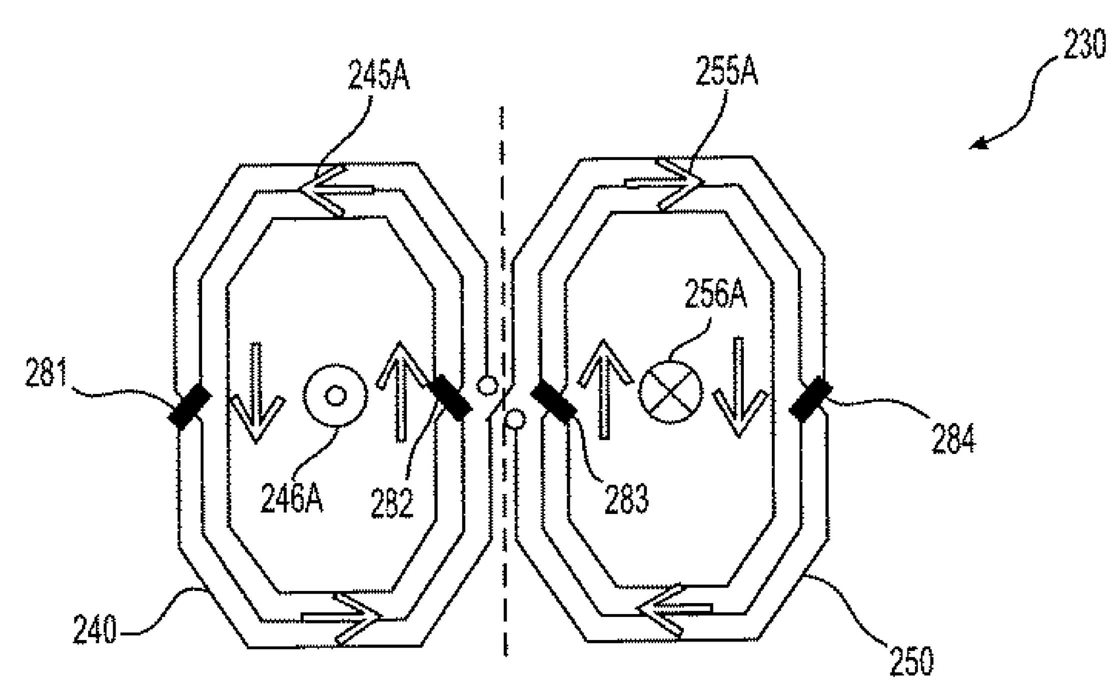
(57) **ABSTRACT**

Aspects of the disclosure provide a device that includes a first inductor. The first inductor includes a first coil portion having more than one turn that defines a first enclosed area and a second coil portion having more than one turn that defines a second enclosed area. The first coil portion and the second coil portion are arranged to generate magnetic fields having substantially equal strength and opposite directions.

16 Claims, 6 Drawing Sheets





(51) **Int. Cl.**

H01F 17/02	(2006.01)
H01F 41/04	(2006.01)
H01F 27/34	(2006.01)
H01L 23/522	(2006.01)
H01F 17/00	(2006.01)

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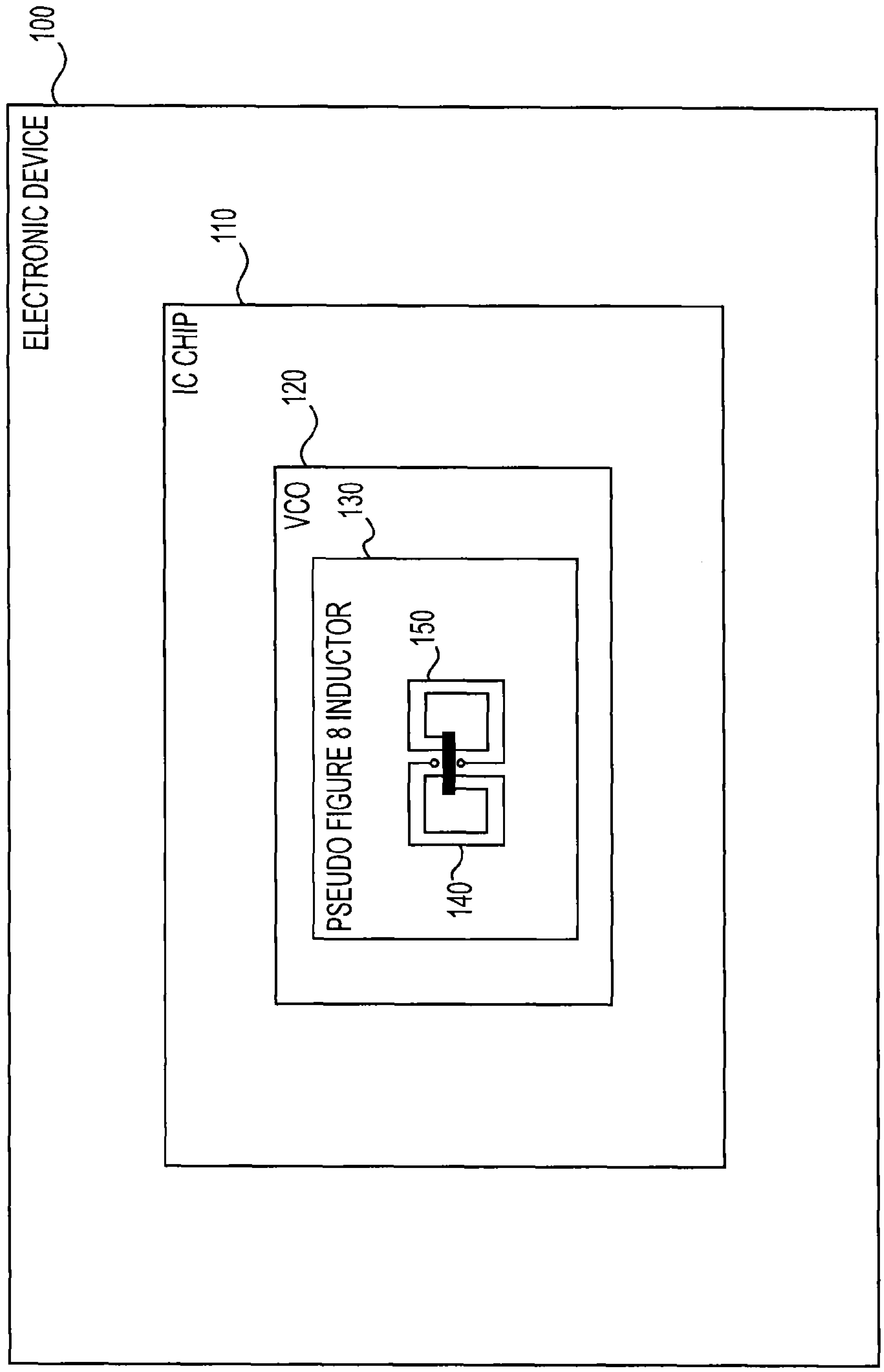
100
ELECTRONIC DEVICE
110
IC CHIP
120
VCO
130
PSEUDO FIGURE 8 INDUCTOR
150
140

FIG. 1

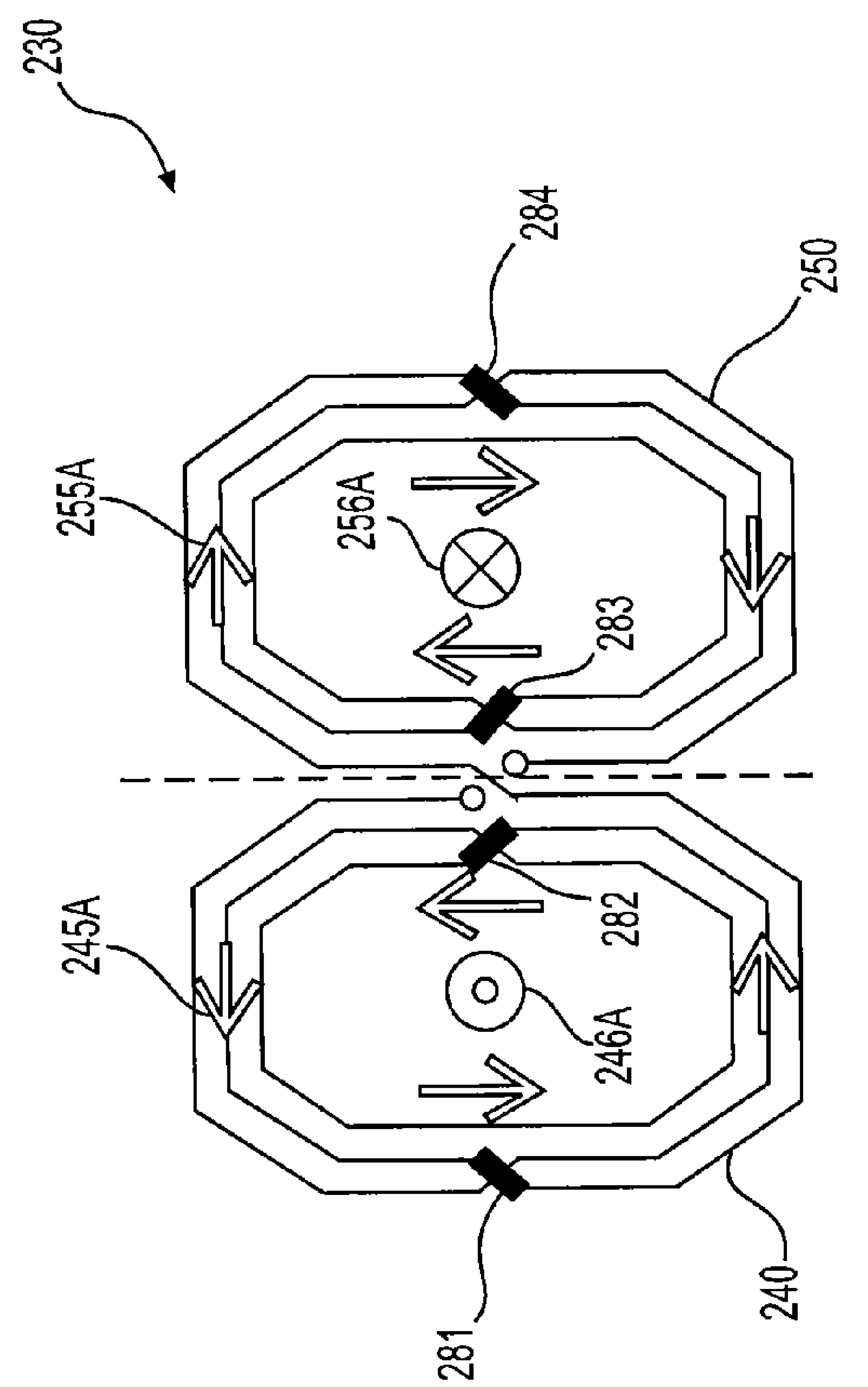
230
284
250
255A
256A
283
245A
282
246A
281
240

FIG. 2A

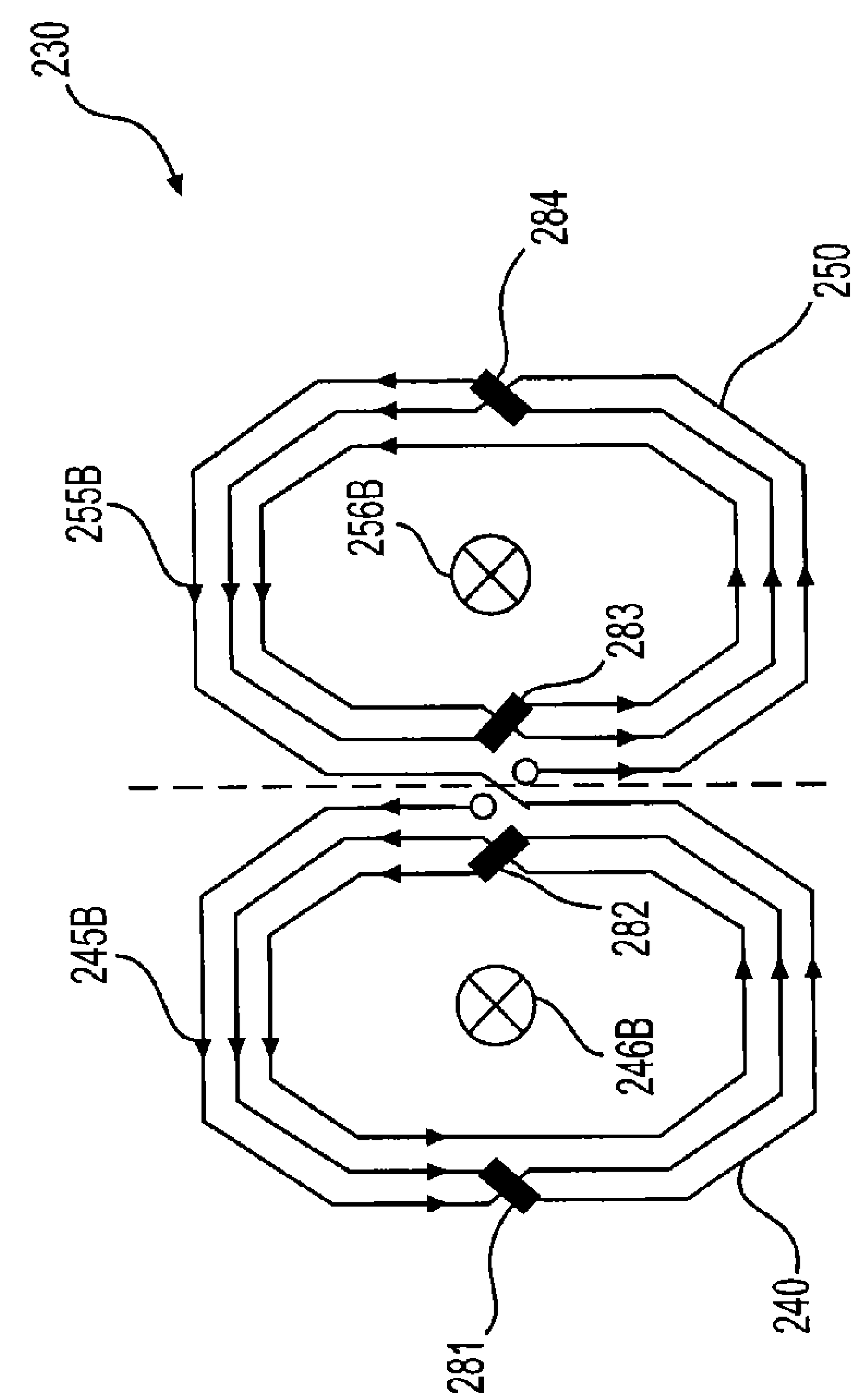
230
284
250
255B
256B
283
245B
282
246B
281
240

FIG. 2B

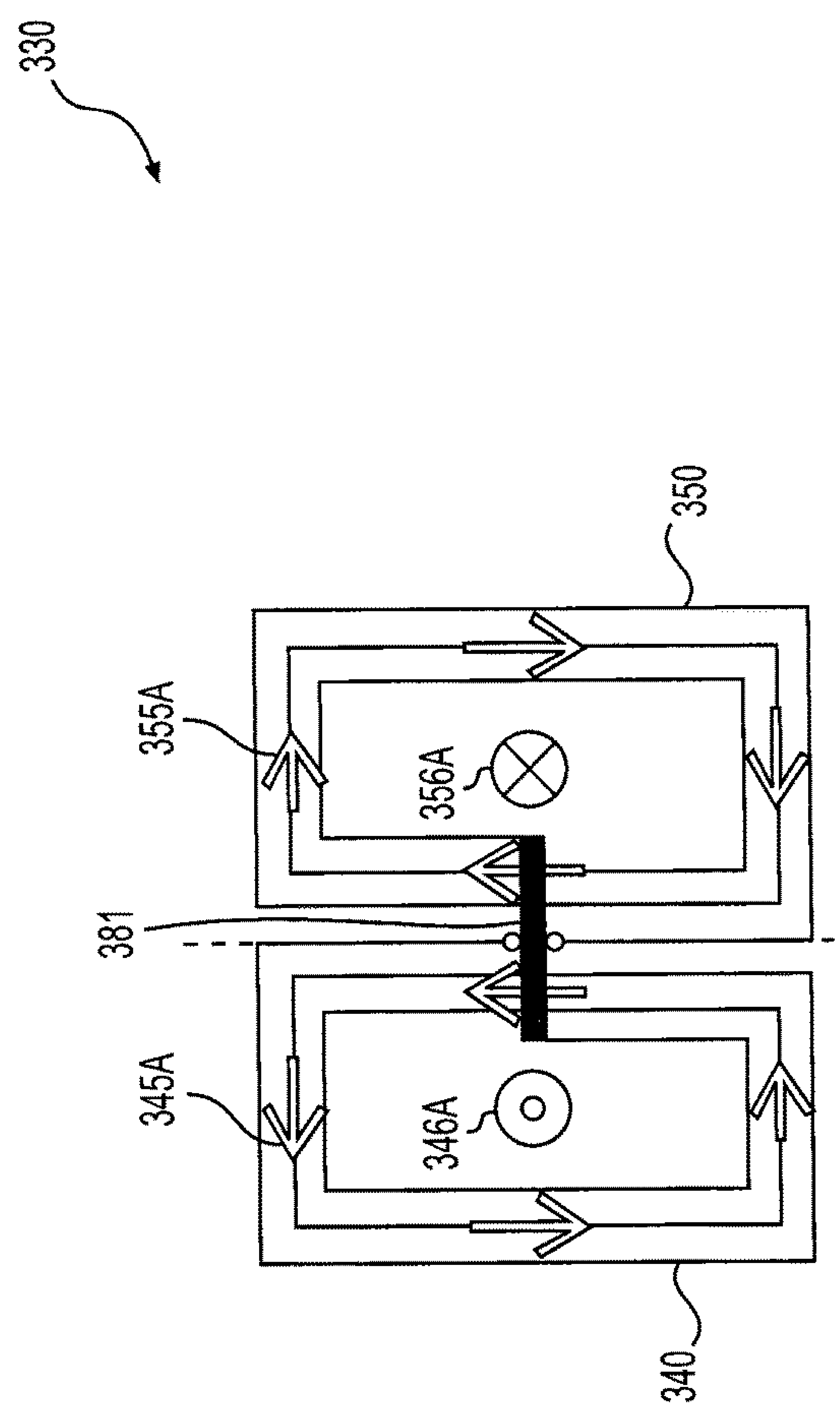
330
350
355A
356A
381
345A
346A
340

FIG. 3A

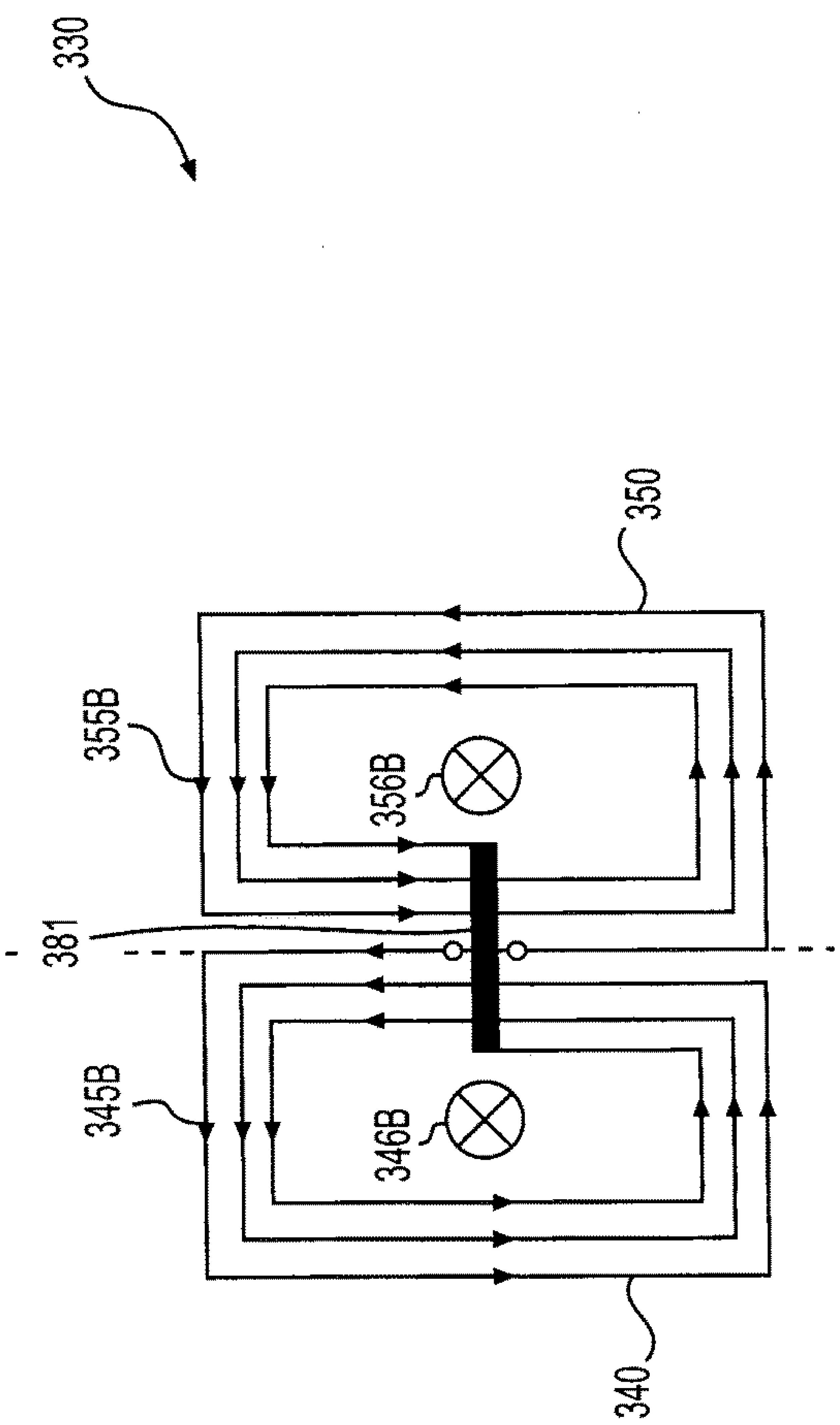
330
350
355B
356B
381
345B
346B
340

FIG. 3B

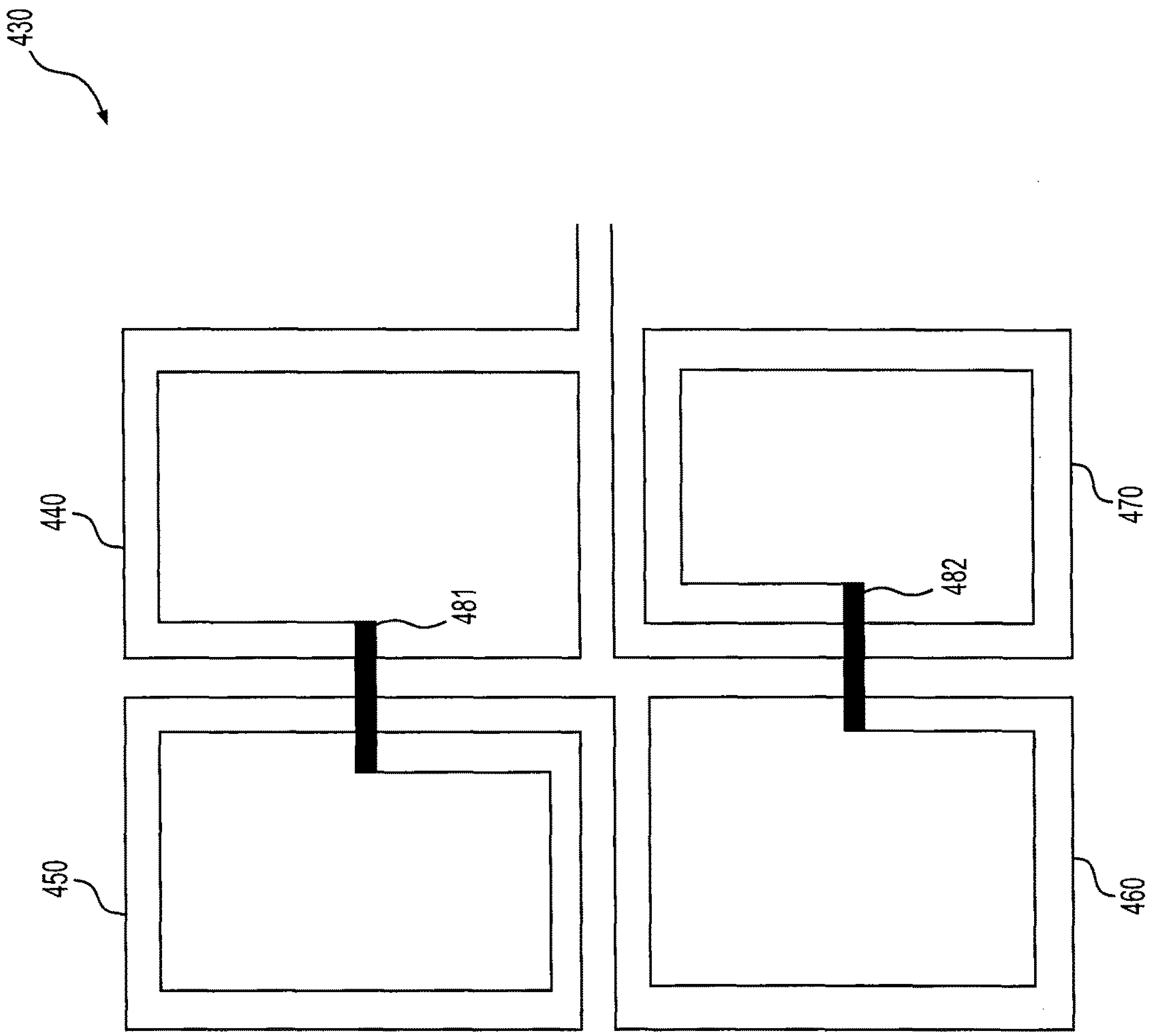

FIG. 4

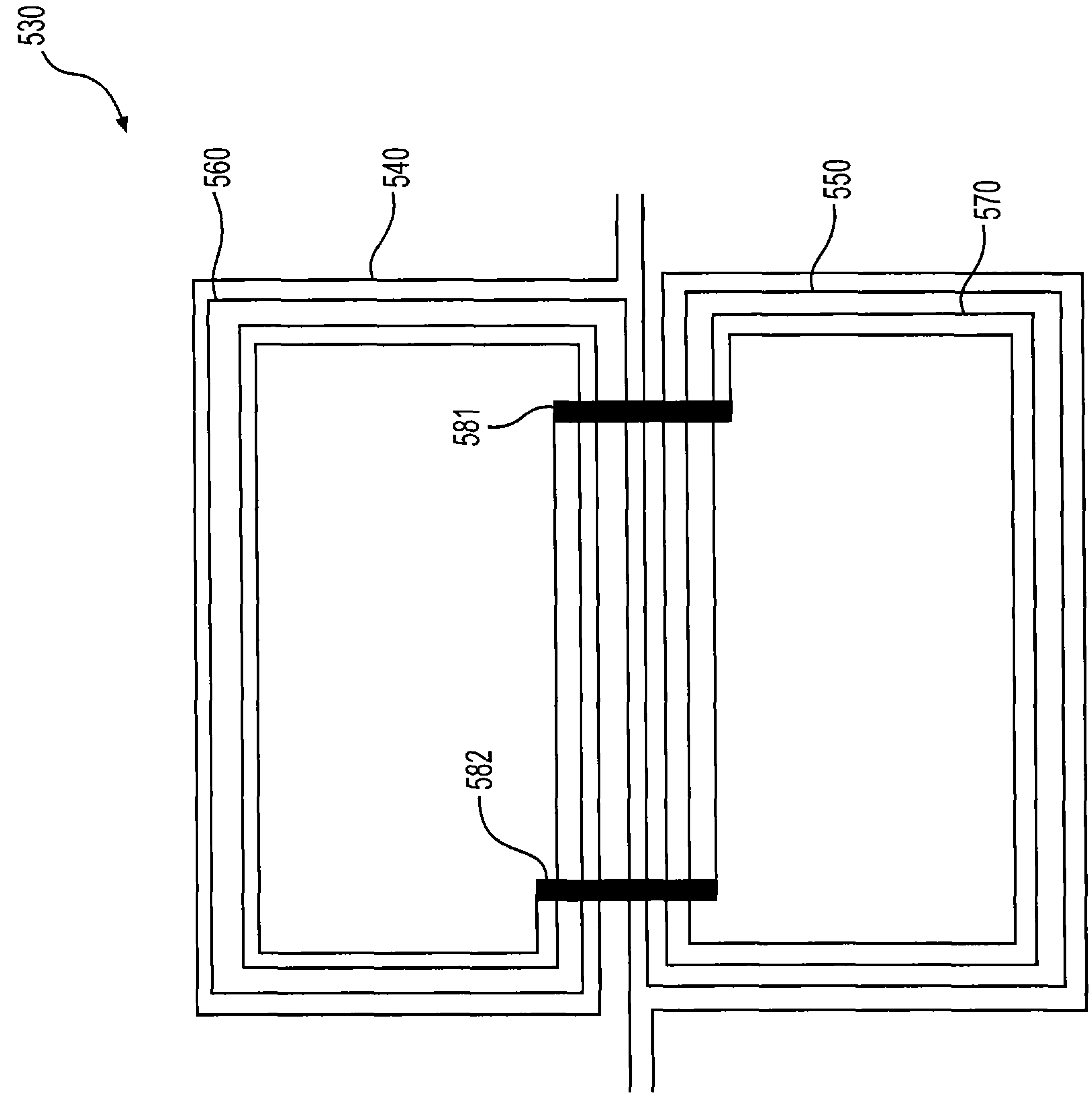

FIG. 5

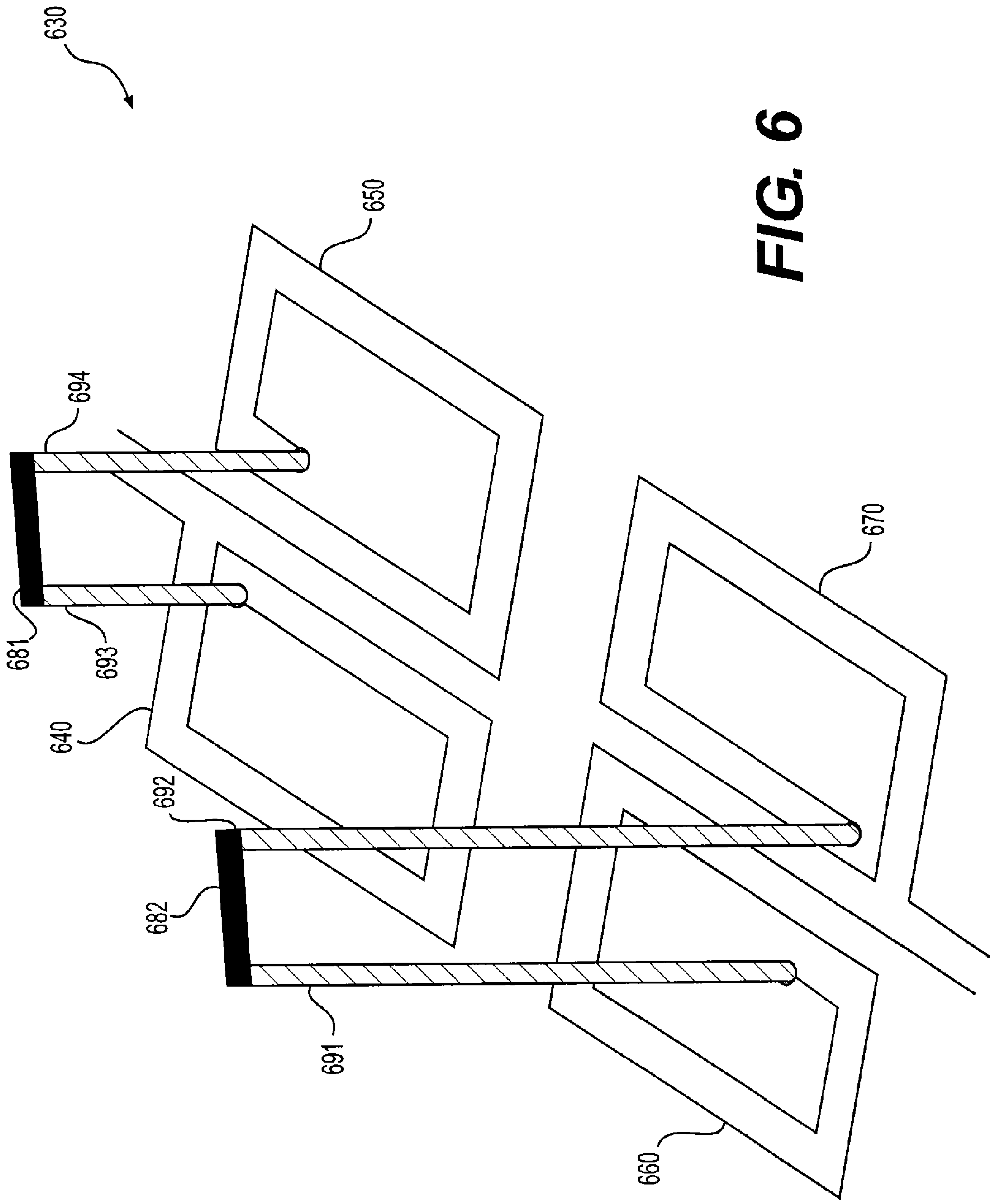

FIG. 6

PSEUDO-8-SHAPED INDUCTOR

INCORPORATION BY REFERENCE

This present disclosure claims the benefit of U.S. Provisional Application No. 61/928,787, "Pseudo-8-shaped Inductor" filed on Jan. 17, 2014, which is incorporated herein by reference in its entirety.

BACKGROUND

The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent the work is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

Inductors are used in various circuits. In an example, an LC-tank based voltage controlled oscillator includes an inductor and a capacitor coupled together to form an LC tank. In another example, a switching regulator includes an inductor to act as an energy storage element.

SUMMARY

Aspects of the disclosure provide a device that includes a first inductor. The first inductor includes a first coil portion having more than one turn that defines a first enclosed area and a second coil portion having more than one turn that defines a second enclosed area. The first coil portion and the second coil portion are arranged to generate magnetic fields having substantially equal strength and opposite directions.

In an embodiment, the first coil portion and the second coil portion are connected in serial in a twisted arrangement that forms a figure-8 shape. In an example, the first coil portion forms a first differential inductor and the second coil portion forms a second differential inductor. In another example, the first coil portion forms a single-ended spiral inductor and the second coil portion forms a second single-ended spiral inductor.

In an embodiment, the first inductor further includes a third coil portion having more than one turn that defines a third enclosed area, and a fourth coil portion having more than one turn that defines a fourth enclosed area. The first coil portion and the second coil portion are connected in serial in a twisted arrangement that forms a first figure-8 shape in a first direction; the second coil portion and the third coil portion are connected in serial in a twisted arrangement that forms a second figure-8 shape in a second direction; the third coil portion and the fourth coil portion are connected in serial in a twisted arrangement that forms a third figure-8 shape in the first direction; and the fourth coil portion and the first coil portion are connected in serial in a twisted arrangement that forms a fourth figure-8 shape in the second direction.

According to an aspect of the disclosure, the first inductor has a single wire from the first enclosed area to the second enclosed area that connects the first coil portion and the second coil portion.

In an embodiment, the first inductor forms a first winding in a transformer, and the device includes a second inductor that forms a second winding in the transformer. The second inductor includes a third coil portion in parallel with the first coil portion in the first enclosed area and a fourth coil portion in parallel with the second coil portion in the second enclosed area. In an example, a majority of the first coil portion, the second coil portion, the third coil portion and the fourth coil portion is formed in a metal layer of an integrated circuit (IC) chip. In another example, a majority of the first coil portion and the second coil portion are formed in a first metal layer of an integrated circuit (IC) chip and a majority of the third coil portion and the fourth coil portion is formed in a second metal layer of the IC chip.

Aspects of the disclosure provide an integrated circuit (IC) chip having an on chip inductor formed on a substrate of the IC chip. The inductor includes a first coil portion having more than one turn that defines a first enclosed area, and a second coil portion having more than one turn that defines a second enclosed area. The first coil portion and the second coil portion are arranged to generate magnetic fields having substantially equal strength and opposite directions.

Aspects of the disclosure provide a method to form an inductor. The method includes forming a first coil portion of the inductor on a substrate. The first coil portion has more than one turn that defines a first enclosed area. Further, the method includes forming a second coil portion of the inductor on the substrate. The second coil portion has than one turn that defines a second enclosed area. Then, the method includes connecting the first coil portion and the second coil portion in a twisted arrangement that forms a figure-8 shape.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of this disclosure that are proposed as examples will be described in detail with reference to the following figures, wherein like numerals reference like elements, and wherein:

FIG. **1** shows a block diagram of an electronic device **100** according to an embodiment of the disclosure;

FIGS. **2**A-**2**B show diagrams of an inductor **230** according to an embodiment of the disclosure;

FIGS. **3**A-**3**B show diagrams of another inductor **330** according to an embodiment of the disclosure;

FIG. **4** shows a diagram of another inductor **430** according to an embodiment of the disclosure;

FIG. **5** shows a diagram of a transformer **530** according to an embodiment of the disclosure; and

FIG. **6** shows a diagram of another transformer **630** according to an embodiment of the disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

FIG. **1** shows a block diagram of an electronic device **100** according to an embodiment of the disclosure. The electronic device **100** includes one or more inductive components, such as an inductor, a transformer, and the like. At least one of the inductive components, such as an inductor **130** in the FIG. **1** example, includes a conductive winding that is formed in a pseudo figure-8 shape. For example, the inductor **130** includes a first coil portion **140** having more than one coil turn that defines a first enclosed area, and includes a second coil portion **150** having more than one coil turn that defines a second enclosed area. The first coil portion **140** and the second coil portion **150** are connected in a twisted arrangement that forms a figure-8 shape, such that the first coil portion **140** and the second coil portion **150** generate magnetic fields having opposite directions.

In the FIG. **1** example, the pseudo figure-8 shape is used to refer to multiple coil turns forming a single figure-8 shape to distinguish from each coil turn forming a figure-8 shape. In an example, the implementation of the inductor **130** saves area, improves quality (Q) factor and self-resonant frequency of the inductor **130** and reduces interference to other circuit components.

The electronic device **100** can be any suitable device, such as a desktop computer, a laptop computer, a tablet computer, a smart phone, a network switch, an access point, a router, a set-top box, a television, and the like, that includes one or more inductive components.

According to an aspect of the disclosure, the electronic device **100** includes an integrated circuit (IC) chip **110**, and the inductor **130** is integrated with other circuit components on the IC chip **110**. In an example, the IC chip **110** includes a voltage-controlled oscillator (VCO) **120** that is an LC-tank based VCO. The inductor **130** and one or more capacitors (not shown) are coupled together to form an LC tank in the VCO **120**.

According to an aspect of the disclosure, the inductor **130** with the winding in the pseudo figure-8 shape has fewer crosses in the winding compared to a related inductor with coil turns in multiple figure-8 shapes. The winding of the related inductor adds two additional crosses per additional coil turn. The winding of the inductor **130** has a reduced number of crosses that simplifies layout complexity, and thus the inductor **130** can be implemented using relatively small silicon area. Further, in an embodiment, a majority of the winding of the inductor **130** is implemented in a first metal layer, and a cross in the winding is implemented in a second metal layer that connects with the first metal layer by via connections. The via connections add resistance to the winding. In an example, the second metal layer has higher sheet resistance than the first metal layer. When the number of crosses in the winding is reduced, the number of via connections is reduced, and the length of metal lines in the second metal layer is reduced, thus the resistance of the winding is reduced. The resistance reduction in the winding improves the Q factor of the inductor **130**.

Further, according to an aspect of the disclosure, due to the twist between the first coil portion **140** and the second coil portion **150**, inductor couplings between the inductor **130** and other inductive components are reduced. In an example, when a current flows in the inductor **130**, the first coil portion **140** and the second coil portion **150** generate magnetic fields of opposite directions. Thus, when the inductor **130** is an aggressor to another inductive component, the magnetic field generated by the first coil portion **140** and the magnetic field generated by the second coil portion **150** completely or partially cancel each other at the other inductive component, and thus the interference of the inductor **130** to the other inductive component is reduced.

When the inductor **130** is a victim to another inductive component, the magnetic field generated by the other inductive component causes internal current in opposite directions in the first coil portion **140** and in the second coil portion **150**. The internal current in the inductor **130** is canceled out. Thus the interference of the other inductive component to the inductor **130** is reduced, and the inductor **130** has an improved Q factor.

According to an aspect of the disclosure, inductor couplings deteriorate various circuit performance. In an example, when the IC chip **110** includes two VCOs to respectively generate two different oscillation frequencies based on two inductors. The inductor couplings of the two inductors can cause local oscillator (LO) pulling and pushing that shift an oscillation frequency from a desired frequency. In another example, when an amplifier uses multiple inductors at different amplify stages, the inductor couplings cause feedback between the amplify stages that deteriorate amplifier performance. In another example, the IC chip **110** includes multiple amplifiers that are independent of each other. The inductor couplings can cause cross-talk between the independent amplifiers that deteriorate amplifier performance.

The inductor **130** with winding in the pseudo figure-8 shape reduces inductor couplings between the inductor **130** and other inductive components, and thus improves circuit performance.

FIGS. **2A-2B** show diagrams of an inductor **230** according to an embodiment of the disclosure. The inductor **230** includes a first coil portion **240** and a second coil portion **250**. The first coil portion **240** includes coil turns that form a first differential inductor and the second coil portion **250** includes coil turns that form a second differential inductor. The first coil portion **240** and the second coil portion **250** are connected in serial in a twisted arrangement that forms a pseudo figure-8 shape.

In the FIGS. **2A** and **2B**, both the first coil portion **240** and the second coil portion **250** have three coil turns. Each of the first coil portion **240** and the second coil portion **250** has two internal crosses, as shown by crosses **281-282** and **283-284**. The first coil portion **240** and the second coil portion **250** are connected without using a cross. Thus, the winding of the inductor **230** has a total of four crosses **281-284**, and each cross needs to cross one coil line. In a related inductor example with coil turns in figure-8 shapes, five or six crosses are needed for three coil turns, and each cross may need to cross three or more coil lines. The winding of the inductor **230** has a reduced number of crosses that simplifies layout complexity, and thus the inductor **230** can be implemented using relatively small silicon area. Further, in an embodiment, a majority of the winding of the inductor **230** is implemented in a first metal layer, such as a copper layer, and a cross in the winding is implemented in a second metal layer, such as an uppermost metal layer which is an aluminum layer (AP), that connects with the first metal layer by via connections. The via connections add resistance to the winding. When the number of crosses in the winding is reduced, the number of via connections is reduced. Further, in an example, the first metal layer has smaller sheet resistance than the second metal layer, and each cross is implemented using a short and wide metal line in the second metal layer to cross a coil line. The use of short and wide metal line in the second metal layer further reduces winding resistance. The resistance reduction in the winding improves the Q factor of the inductor **230**.

Further, according to an aspect of the disclosure, each of the differential inductors is configured into a single-ended inductor. The inductor **230** has a reduced parasitic capacitance compared to the related inductor example. In an example, because of the parasitic capacitance reduction, the inductor **230** has a higher self-resonant frequency than the related inductor example with coil turns in figure-8 shapes.

FIG. **2A** shows current and magnetic fields when the inductor **230** is an aggressor inductor to a victim inductive component (not shown) according to an embodiment of the disclosure. When a current flows in the inductor **230**, due to the twist between the first coil portion **240** and the second coil portion **250**, the current flows in opposite directions in the first coil portion **240** and the second coil portion **250**. In the FIG. **2A** example, the current flows in the first coil portion **240** in a counterclockwise direction as shown by **245**A, and generates a first magnetic field with a direction pointing out of the page as shown by **246**A; and the current flows in the second coil portion **250** in a clockwise direction as shown by **255**A and generates a second magnetic field with a direction pointing into the page as shown by **256**A. The first magnetic field and the second magnetic field have opposite directions. When the first coil portion **240** and the second coil portion **250** have substantially the same shape and size, the first magnetic field and the second magnetic field have about the same strength but different directions. Thus, the first magnetic field and the second magnetic field cancel out each other's affect to the victim inductive component, and cause little interference to the victim inductive component.

FIG. **2**B shows current and magnetic fields when the inductor **230** is a victim inductor to an aggressor inductive component (not shown) according to an embodiment of the disclosure. The other inductive component generates a magnetic field that may induce current in the inductor **230**. In the FIG. **2**B example, the magnetic field in the first coil portion **240** is shown as **246**B and may cause a first current flowing in the first coil portion **240** as shown by **245**B. The magnetic field in the second coil portion **250** is shown as **256**B, and may cause a second current flowing in the second coil portion **250** as shown by **255**B. Due to the twist between the first coil portion **240** and the second coil portion **250**, the first current and the second current cancel each other, thus no current flows in the inductor **230** due to the magnetic field generated by the aggressor inductive component.

FIGS. **3**A-**3**B show diagrams of another inductor according to an embodiment of the disclosure. The inductor **330** includes a first coil portion **340** and a second coil portion **350**. The first coil portion **340** includes coil turns that form a first spiral inductor and the second coil portion **350** includes coil turns that form a second spiral inductor. The first coil portion **340** and the second coil portion **350** are connected in serial in a twisted arrangement that forms a pseudo figure-8 shape.

In the FIGS. **3**A and **3**B, both the first coil portion **340** and the second coil portion **350** have three coil turns, and the winding of the inductor **330** has one cross **381**. In a related inductor example with coil turns in figure-8 shapes, five or six crosses are needed. The winding of the inductor **330** has a single cross that simplifies layout complexity, and thus the inductor **330** can be implemented using relatively small silicon area. Further, in an embodiment, a majority of the winding of the inductor **330** is implemented in a first metal layer, such as a copper metal layer, and the cross in the winding is implemented in a second metal layer, such as an uppermost metal layer which is an aluminum layer (AP), that connects with the first metal layer by via connections. The via connections add resistance to the winding. When the number of crosses in the winding is reduced, the number of via connections is reduced, thus the resistance of the winding is reduced. In addition, in an example, a wider AP metal line is used to further reduce resistance. The resistance reduction in the winding improves the Q factor of the inductor **330**.

Further, according to an aspect of the disclosure, the spiral inductors are single-ended inductors, thus the inductor **330** has a reduced parasitic capacitance compared to the related inductor example. In an example, because of the reduced parasitic capacitance, the inductor **330** has a higher self-resonant frequency than the related inductor example.

FIG. **3**A shows current and magnetic fields when the inductor **330** is an aggressor inductor to a victim inductive component (not shown) according to an embodiment of the disclosure. When a current flows in the inductor **330**, due to the twist between the first coil portion **340** and the second coil portion **350**, the current flows in opposite directions in the first coil portion **340** and the second coil portion **350**. In the FIG. **3**A example, the current flows in the first coil portion **340** in a counterclockwise direction as shown by **345**A, and generates a first magnetic field with a direction pointing out of the page as shown by **346**A; and the current flows in the second coil portion **350** in a clockwise direction as shown by **355**A and generates a second magnetic field with a direction pointing into the page as shown by **356**A. The first magnetic field and the second magnetic field have opposite directions. When the first coil portion **340** and the second coil portion **350** have substantially the same shape and size, the first magnetic field and the second magnetic field have about the same strength but different directions. Thus, the first magnetic field and the second magnetic field cancel out each other's affect to the victim inductive component, and cause little interference to the victim inductive component.

FIG. **3**B shows current and magnetic fields when the inductor **330** is a victim inductor to an aggressor inductive component (not shown) according to an embodiment of the disclosure. The aggressor inductive component generates a magnetic field that may induce current in the inductor **330**. In the FIG. **3**B example, the magnetic field in the first coil portion **340** is shown as **346**B and may cause a first current flowing in the first coil portion **340** as shown by **345**B. The magnetic field in the second coil portion **350** is shown as **356**B, and may cause a second current flowing in the second coil portion **350** as shown by **355**B. Due to the twist between the first coil portion **340** and the second coil portion **350**, the first current and the second current cancel each other, thus no current flows in the inductor **330** due to the magnetic field generated by the aggressor inductive component.

FIG. **4** shows a diagram of another inductor **430** according to an embodiment of the disclosure. The inductor **430** includes a first coil portion **440**, a second coil portion **450**, a third coil portion **460** and a fourth coil portion **470**. The first coil portion **440** includes coil turns that form a first spiral inductor, the second coil portion **450** includes coil turns that form a second spiral inductor, the third coil portion **460** includes coil turns that form a third spiral inductor, and the fourth coil portion **470** includes coil turns that form a fourth spiral inductor. The first coil portion **440** and the second coil portion **450** are connected in serial in a twisted arrangement that forms a pseudo figure-8 shape in a first direction, such as X direction; the second coil portion **450** and the third coil portion **460** are connected in serial in a twisted arrangement that forms a pseudo figure-8 shape in a second direction, such as Y direction; the third coil portion **460** and the fourth coil portion **470** are connected in serial in a twisted arrangement that forms a pseudo figure-8 shape in the first direction; and the fourth coil portion **470** and the first coil portion **440** are connected in serial in a twisted arrangement that forms a pseudo figure-8 shape in the second direction.

In the FIG. **4** example, each of the coil portions **440**-**470** has two coil turns, and the winding of the inductor **430** has two crosses **481** and **482**. The winding of the inductor **430** simplifies layout complexity, and thus the inductor **430** can be implemented using relatively small silicon area. Further, in an embodiment, a majority of the winding of the inductor **430** is implemented in a first metal layer, such as a copper metal layer, and the crosses in the winding are implemented in a second metal layer, such as an uppermost metal layer which is an aluminum layer (AP), that connects with the first metal layer by via connections. The via connections add resistance to the winding. When the number of crosses in the winding is reduced, the number of via connections is reduced, thus the resistance of the winding is reduced. In addition, in an example, a wider AP metal line is used to further reduce resistance. The resistance reduction in the winding improves the Q factor of the inductor **430**.

Further, according to an aspect of the disclosure, the spiral inductors are single-ended inductors, thus the inductor **430** has a reduced parasitic capacitance compared to the related inductor example. In an example, because of the reduced parasitic capacitance, the inductor **430** has a higher self-resonant frequency than the related inductor example.

In the FIG. **4** example, the winding of the inductor **430** forms figure-8 shapes in both the X direction and the Y direction. Similar to the analysis in FIG. **3**A, when the inductor **430** is an aggressor to a victim inductive component, the magnetic fields generated by the winding portions **440-470** cancel in both the X direction and the Y direction, and cause little interference to the victim inductive component in any of the X direction and Y direction. Similar to the analysis in FIG. **3**B, when the inductor **430** is a victim to an aggressor inductive component, due to the twists that form the figure-8 shapes, current generated in the winding portions **440-470** cancels each other. Thus, no current flows in the inductor **430** due to the magnetic field generated by the aggressor inductive component.

FIG. **5** shows a diagram of a transformer **530** according to an embodiment of the disclosure. The transformer **530** includes a first winding having a first coil portion **540** and a second coil portion **550**, and a second winding having a third coil portion **560** and a fourth coil portion **570**. The first coil portion **540** includes coil turns that form a first spiral inductor and the second coil portion **550** includes coil turns that form a second spiral inductor. The first coil portion **540** and the second coil portion **550** are connected in serial in a twisted arrangement that forms a pseudo figure-8 shape. The third coil portion **560** includes coil turns that form a third spiral inductor and the fourth coil portion **570** includes coil turns that form a fourth spiral inductor. The third coil portion **560** and the fourth coil portion **570** are connected in serial in a twisted arrangement that forms a pseudo figure-8 shape.

In the FIG. **5** example, the transformer **530** is a 1:1 transformer in which the first winding and the second winding have about the same area size and the same number of coil turns. Specifically, coil turns in the first coil portion **540** and the third coil portion **560** are interleaved to be parallel, and coil turns in the second coil portion **550** and the fourth coil portion **570** are interleaved to be parallel.

In the FIG. **5** example, the windings of the transformer **530** have two crosses **581** and **582** that simplify layout complexity, and thus the transformer **530** can be implemented using relatively small silicon area. Further, in an embodiment, a majority of the windings of the transformer **530** is implemented in a first metal layer, such as a copper metal layer, and the crosses **581** and **582** in the windings are implemented in a second metal layer, such as an uppermost metal layer which is an aluminum layer (AP), that connects with the first metal layer by via connections. The via connections add resistance to the winding. When the number of crosses in the windings is reduced, the number of via connections is reduced, thus the resistance of the windings is reduced. In addition, in an example, wider AP metal lines are used to further reduce resistance. The resistance reduction in the winding improves the Q factor of the transformer **530**.

Further, according to an aspect of the disclosure, the spiral inductors in the transformer **530** are single-ended inductors, thus the transformer **530** has a reduced parasitic capacitance. In an example, because of the parasitic capacitance reduction, the transformer **530** achieves a higher self-resonant frequency.

FIG. **6** shows a diagram of another transformer **630** according to an embodiment of the disclosure. The transformer **630** includes a first winding having a first coil portion **640** and a second coil portion **650**, and a second winding having a third coil portion **660** and a fourth coil portion **670**. The first coil portion **640** includes coil turns that form a first spiral inductor and the second coil portion **650** includes coil turns that form a second spiral inductor. The first coil portion **640** and the second coil portion **650** are connected in serial in a twisted arrangement that forms a pseudo figure-8 shape. The third coil portion **660** includes coil turns that form a third spiral inductor and the fourth coil portion **670** includes coil turns that form a fourth spiral inductor. The third coil portion **660** and the fourth coil portion **670** are connected in serial in a twisted arrangement that forms a pseudo figure-8 shape.

In the FIG. **6** example, the windings of the transformer **630** have two crosses **681** and **682** that simplify layout complexity, and thus the transformer **630** can be implemented using relatively small silicon area. Further, in the FIG. **6** example, a majority of the first winding of the transformer **630** is implemented in a first metal layer, such as a first copper metal layer, a majority of the second winding of the transformer **630** is implemented in a second metal layer, such as a second copper metal layer. The cross **681** in the first winding is implemented in a third metal layer, such as an uppermost metal layer which is an aluminum layer (AP), that connects with the first metal layer by via connections **693** and **694**. In the FIG. **6** example, the cross **682** in the second winding is also implemented in the third metal layer that connects to the second metal layer by via connections **691** and **692**.

In an example, a majority of the first winding and the second winding are stacked on the silicon substrate with one or more dielectric layers between the two metal layers. In an example, the patterns of the first winding and the second winding overlap to save silicon area. It is noted that the first metal layer and the second metal layer can be the same or different sheet resistance.

The transformer **630** has a relatively small number of crosses in the windings, thus the resistance of the windings is reduced. In addition, in an example, wider AP metal lines are used to further reduce resistance. The resistance reduction in the winding improves the Q factor of the transformer **630**.

Further, according to an aspect of the disclosure, the spiral inductors in the transformer **630** are single-ended inductors, thus the transformer **630** has a reduced parasitic capacitance. In an example, because of the parasitic capacitance reduction, the transformer **630** achieves a higher self-resonant frequency.

While aspects of the present disclosure have been described in conjunction with the specific embodiments thereof that are proposed as examples, alternatives, modifications, and variations to the examples may be made. Accordingly, embodiments as set forth herein are intended to be illustrative and not limiting. There are changes that may be made without departing from the scope of the claims set forth below.

What is claimed is:

1. A device, comprising:

a first inductor comprising:

a first coil portion having more than one turn that defines a first enclosed area; and a second coil portion having more than one turn that defines a second enclosed area,

wherein the first coil portion and the second coil portion are arranged to generate magnetic fields having substantially equal strength and opposite directions, and the first coil portion twisted in a first direction and the second coil portion twisted in a second direction that is different from the first direction, the first coil portion having a first pair of internal crosses crossing the first coil portion, the second coil portion having a second pair of internal crosses crossing the second coil portion, the first coil portion and the second coil portion being coupled without using any of the first and second pairs of internal crosses, the first inductor being implemented in a first metal layer, and the first and second pairs of internal crosses being implemented in a second metal layer that has a higher sheet resistance than the first metal layer.

2. The device of claim **1**, wherein the twisted arrangement forms a figure-8 shape.

3. The device of claim **1**, wherein the first coil portion forms a first differential inductor and the second coil portion forms a second differential inductor.

4. The device of claim **1**, wherein the first coil portion forms a single-ended spiral inductor and the second coil portion forms a second single-ended spiral inductor.

5. The device of claim **1**, wherein the first inductor has a single wire from the first enclosed area to the second enclosed area that couples the first coil portion and the second coil portion.

6. The device of claim **1**, wherein the first inductor forms a first winding in a transformer, the device further comprises:

a second inductor comprising:

a third coil portion in parallel with the first coil portion in the first enclosed area; and

a fourth coil portion in parallel with the second coil portion in the second enclosed area, the second inductor forming a second winding in the transformer.

7. The device of claim **6**, wherein a majority of the first coil portion, the second coil portion, the third coil portion and the fourth coil portion is formed in the first metal layer of an integrated circuit (IC) chip.

8. The device of claim **6**, wherein a majority of the first coil portion and the second coil portion are formed in the first metal layer of an integrated circuit (IC) chip and a majority of the third coil portion and the fourth coil portion is formed in a third metal layer of the IC chip.

9. An integrated circuit (IC) chip, comprising:

a first inductor formed on a substrate of the IC chip, the first inductor comprising:

a first coil portion having more than one turn that defines a first enclosed area; and

a second coil portion having more than one turn that defines a second enclosed area,

wherein the first coil portion and the second coil portion are arranged to generate magnetic fields having substantially equal strength and opposite directions, the first coil portion twisted in a first direction and the second coil portion twisted in a second direction that is different from the first direction, the first coil portion having a first pair of internal crosses crossing the first coil portion, the second coil portion having a second pair of internal crosses crossing the second coil portion, the first coil portion and the second coil portion being coupled without using any of the first and second pairs of internal crosses, the first inductor being implemented in a first metal layer, and the first and second pairs of internal crosses being implemented in a second metal layer that has a higher sheet resistance than the first metal layer.

10. The IC chip of claim **9**, wherein the twisted arrangement forms a figure-8 shape.

11. The IC chip of claim **9**, wherein the first coil portion forms a first differential inductor and the second coil portion forms a second differential inductor.

12. The IC chip of claim **9**, wherein the first coil portion forms a single-ended spiral inductor and the second coil portion forms a second single-ended spiral inductor.

13. The IC chip of claim **9**, wherein the first inductor has a single wire from the first enclosed area to the second enclosed area that couples the first coil portion and the second coil portion.

14. The IC chip of claim **9**, wherein the first inductor forms a first winding in a transformer, the IC chip further comprises:

a second inductor comprising:

a third coil portion in parallel with the first coil portion in the first enclosed area; and

a fourth coil portion in parallel with the second coil portion in the second enclosed area, the second inductor forming a second winding in the transformer.

15. The IC chip of claim **14**, wherein a majority of the first coil portion, the second coil portion, the third coil portion and the fourth coil portion is formed in the first metal layer of the IC chip.

16. The IC chip of claim **14**, wherein a majority of the first coil portion and the second coil portion are formed in the first metal layer of the IC chip and a majority of the third coil portion and the fourth coil portion is formed in a third metal layer of the IC chip.

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